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An Assessment of Simulation Systems Applicable to Business Process Reengineering at Army Directorates of Public Works

by
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All agencies of the Federal Government, including Army Directorates of Public Works (DPWs), are starting to apply business reengineering to improve current processes and reduce resource requirements. Currently, these Directorates have no way of forecasting and examining effects of proposed changes.

The objective of this research was to evaluate and select a marketed simulation system that is optimal for use by DPWs during business reengineering planning and operations analyses.

Seven simulation systems were evaluated and three were selected for detailed analysis and testing. Based on the documentation and available tutorial, ease of use, and capabilities, PROMODEL is recommended for use in DPW business process reengineering.

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The objective of this research was to evaluate and select a marketed simulation system that is optimal for use by DPWs during business reengineering planning and operations analyses.

Seven simulation systems were evaluated and three were selected for detailed analysis and testing. Based on the documentation and available tutorial, ease of use, and capabilities, PROMODEL is recommended for use in DPW business process reengineering.

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Foreword

This study was conducted for U.S. Army Center for Public Works (USACPW) under Project 4A162784AT41, "Military Facilities Engineering Technology"; Work Unit FF-AY4, "DPW Process Improvement Analysis." The technical monitor was Leo Oswalt, CECPW-SB.

The work was performed by the Facility Management Division (FF) of the Infrastructure Laboratory (FL), U.S. Army Construction Engineering Research Laboratories (USACERL). Alan Moore is Chief, CECER-FF, and Dr. David M. Joncich is Acting Chief, CECER-FL. The USACERL technical editor was Gloria J. Wienke, Information Management Office.

LTC David J. Rehbein is Commander and Acting Director of USACERL, and Dr. Michael J. O'Connor is Technical Director.

Contents

1 Introduction

Background

All agencies of the Federal Government, including Army Directorates of Public Works (DPWs), are starting to apply business reengineering to improve current processes and reduce resource requirements. Currently, the DPWs have no way of forecasting and examining effects of proposed changes without the disruption of making an actual procedural change. They need answers to "what if" questions, which can be produced by a business process simulation system, to ensure a wide range of considerations for revamping and improving the structural and functional procedures of a DPW.

Objective

The objective of this research was to evaluate and select a marketed simulation system that is optimal for use by DPWs during business reengineering planning and operations analyses.

Approach

Researchers conducted a literature search to determine the state of the art in business process simulation systems. They then contacted simulation model developers and major vendors to acquire defining documentation and to determine which simulation systems are most useful in business reengineering. The final introductory step was to review the documentation to determine the systems' modeling/simulation capabilities and general applicability.

Based on the literature provided by developers and vendors, researchers selected three modeling systems for detailed testing: SIMPROCESS, WITNESS, and PROMODEL The U.S. Army Center for Public Works (USACPW) identified a business process reengineering task that researchers then modeled using each system. The results were compared and one system was recommended for use in business process reengineering.

Scope

This research was limited to evaluation of completely functional modeling systems that run on the MS-DOS based personal computers (PCs) with a Windows* operating system that are common in most DPWs.

Mode of Technology Transfer

It is anticipated that access to the selected business process modeling system by the DPWs will be through the U.S. Army Center for Public Works (CECPW), Fort Belvoir, VA.

* MS-DOS and Windows are registered trademarks of Microsoft Corporation.

2 Computer Simulations: A State-of-the-Art Determination

Current Simulation Systems

A literature search identified many simulation systems that are being applied to a wide variety of processes including power plants, factories, hospitals, banks, etc. Researchers also contacted modeling and simulation societies and simulation package vendors for information.

The two international societies that maintain information related to simulation systems are: the Society for Computer Simulation (SCS) and the IDEF Users Group (IDEF UG). The SCS is the largest society and maintains a directory of over 130 simulation software packages. It can be reached at:

Society for Computer Simulation
4838 Ronson Court, Suite L
P. O. Box 17900, San Diego, CA 92177
Telephone: (619)277-3888
FAX (619)277-3930.

The IDEF UG maintains a products and services guide. It can be reached at:

IDEF Users Group, An Association for
Enterprise System Integration Methods
1900 Founders Drive, Kettering, OH 45420
Telephone (513)259-4702.

A letter of inquiry was sent to major simulation system vendors. The letter stated that the USACPW was in the process of selecting a simulation system for business reengineering and if the vendor was marketing their system for business reengineering their system literature would be reviewed if submitted.

Review copies of the systems were requested from the seven vendors listed in Table 1. Although, some vendors provided evaluation systems that were smaller in the number of entries than the full system, they said the capabilities of those

Table 1. Simulation systems requested for review.

System Name	Company	Contact
PACE	Anilam Electronics 5625 NW 79TH Ave Miami, FL 33166	Larry Mize 305-592-2727
WITNESS	AT&T ISTEL 25800 Science Park Drive Beachwood, OH 44122	Scott Broker 708-437-2444
SIMPROCESS	CACI Products Company 3333 N. Toney Pines Ct. La Jolla, CA 92037	Hal Duncan 619-457-9681
MICRO SAINT	Micro Analysis & Design 4900 Pearl East Circle Suite 201 E Boulder, CO 80301	Lori Hood 303-442-6947
PROMODEL	PROMODEL 1875 South State Suite 3400 Orem, UT 84058	Bruce Gladwin 801-226-6036
ProTEM	Software Consultants Int. P. O. Box 5712 Kent, WA 98064-5712	Larry Peters 206-631-4212
ARENA	Systems Modeling Corp. Park Building 504 Beaver St. Sewickley, PA 15143	Adrian Wood 412-741-5635

systems were identical. However, a simplified evaluation system will normally run faster than the full system.

Qualifying Criteria

All Army DPWs have MS-DOS based PCs, and many are in the process of moving to the Windows operating system. A primary criterion for simulation system evaluation was that it run in this environment. Other criteria included: simplicity, ease of use, transparency of operation, and general fieldability.

Basic System Review

The manufacturer/vendor literature was reviewed to determine system capabilities. Several companies provided on line training or offered a regularly scheduled or special training course. All of the simulation systems were originally designed for a purpose other than business reengineering. Some vendors were in the

process of adding new features for business reengineering that would be released in the near future.

General assessments were made of the documentation to determine each system's release and revision history, the number and level of simulation features, any parallel processing limitations, ability to process graphics, automated statistical aids, and custom reporting capabilities. Demonstration models provided indications of user friendliness and complexities.

Conclusions

All of the systems were strong graphically and all generally were more powerful than the requirements of a basic DPW reengineering process. Each system, however, used different definitions for items and had different methods for implementing the same basic functions,

After initial evaluation, it was evident that any of the seven systems could be used to perform business reengineering functions. Because time and resources were not available to completely test every system, the three most promising systems (SIMPROCESS, WITNESS, and PROMODEL) were selected for detailed analysis and testing.

3 Army Integrated Computer Aided Manufacturing Definition (IDEF) Modeling and Simulation

Current IDEF Modeling

The USACPW has been active in using the IDEF flow charting definition standard for determining both automation and improvement areas within current DPW processes. The most extensive use of IDEF has been to develop the activity model to manage real property facilities and provide related services.

The USACPW selected one typical area to be used for the simulation test. The most detailed IDEF diagram is given in Figure 1. Note that the development of an IDEF0 or IDEF1 model for a process does not imply that the process is or should be simulated; the model is an analytical tool in itself.

Minimum Process Simulation Requirements

The IDEF model in Figure 1 was expanded to form a very basic simulation process as shown in Figure 2. The Appendix lists the minimum amount of information required to perform a basic simulation. The simulation model in Figure 2 and the associated data should not be considered to represent the needs of an actual DPW. Although the flow and data developed are representative of simulation modeling needs, they are used here for the sole purpose of having a typical model to test the simulation systems.

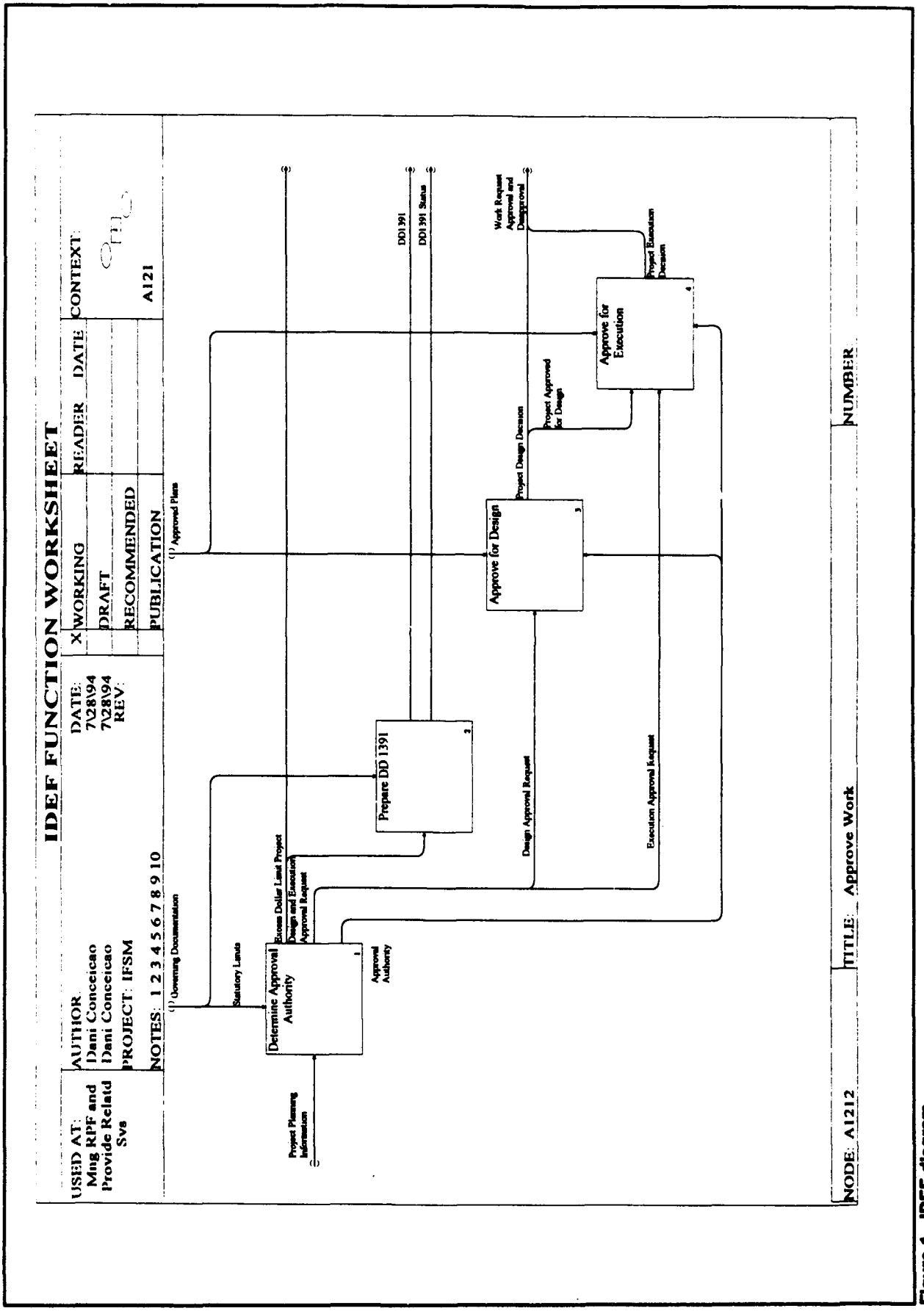

Figure 1. IDEF diagram.

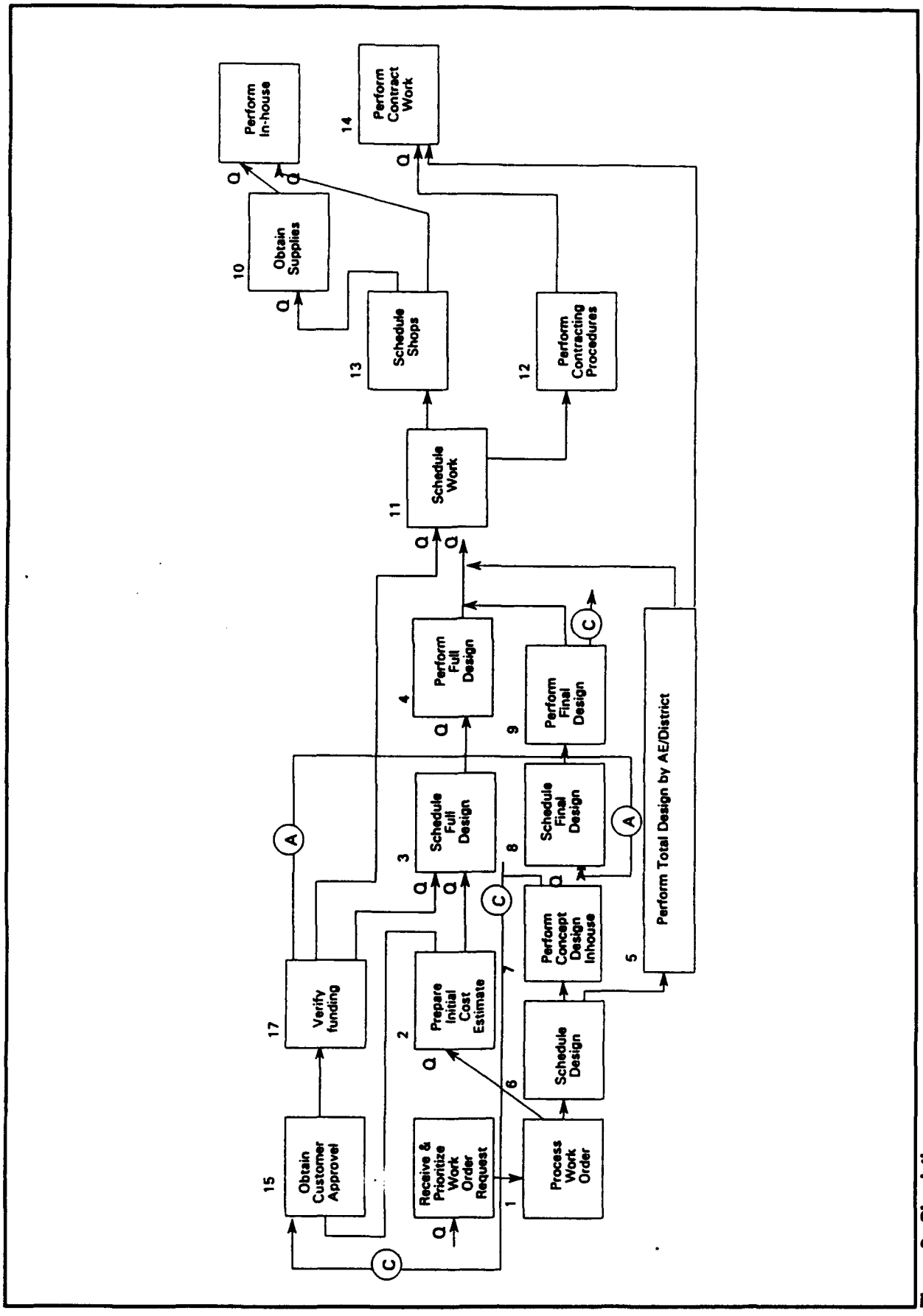

Figure 2. Simulation process.

4 System Comparison

Evaluation Criteria

The evaluation criteria consisted of determining the simplicity and ease of use of the system by DPW staff members who would be involved in simulating the business reengineering processes.

Preliminary screening assessments were made of the submitted packages. The documentation provided a means of determining the release/revision history, the number/level of simulation features, any parallel processing limitations, ability to process graphics, automated statistical aids, and summary activity or total process reporting capabilities. Demonstration or test simulation models also provided indications of user friendliness and whether needless complexities were included.

A review of the demonstration packages and documentation resulted in three systems being selected for detailed analysis: SIMPROCESS, WITNESS, and PROMODEL. The detailed analysis consisted of modeling the process in Figure 2. The analysis was conducted in the context of DPW Business Process Reengineering capabilities, Army process applicability, and the user friendliness of the software to a typical Army user's capabilities.

SIMPROCESS Evaluation

General

The logic of SIMPROCESS is entity based. The complete path of individual units through a process must be specified.

Advantage

One advantage of SIMPROCESS is the animation, which shows the number of work orders that has begun and completed a certain activity during a simulation run. This is helpful in verifying and demonstrating the simulation of the model.

Disadvantages

The use of attributes and expressions is confusing and often leads to errors in the modeling process. For instance, setting the cost of a certain work order is difficult. In most simulation languages, a line of code such as "cost = 1" or "cost = high" would be sufficient. In SIMPROCESS, the equivalent line of code is "atr[cost(self)] = 1."

Editing in SIMPROCESS is cumbersome. Several windows must be opened before reaching the editing mode. It is quicker to edit manually from a file or to copy lines of code.

The complete path of an item through a process must be specified. This can be laborious as seen in Figure 3. This figure shows the command list for just two activities and just one type of work order. Considering the number of activities and the number of different work orders involved, the entity based logic of SIMPROCESS is not efficient.

```
request
    RESOURCE ProcWO
    Count: 1.0
    Cond expression: 0
    Conditions: 0
work
    time: 8.0
release
    RESOURCE ProcWO
    Count: 1.0
    Cond expression: 0
    Conditions: 0
evaluate cod[
    let atr[stts(self)] = 2.0]
evaluate cod[
    let atr[trec(self)] = time]
request
    RESOURCE SchDes
    Count: 1.0
    Cond expression: 0
    Conditions: 0
work
    time: 3.0
release
    RESOURCE SchDes
    Count: 1.0
    Cond expression: 0
    Conditions: 0
```

Figure 3. A typical command list for a work order in a SIMPROCESS model.

Functional Characteristics

SIMPROCESS has no convenient way to use global variables (e.g., a record of the current calendar year). In most simulation packages, a variable can be created and assigned a value. In SIMPROCESS, a separate entity must be created and given an attribute; then values are assigned to that attribute.

Another difficulty is that a work order cannot be simply changed from "new" to "subject to availability of funds." SIMPROCESS requires you to remove one work order ("new") and then create another ("subject to availability of funds") in its place.

A valid model needs to include the ability to simulate lunch breaks, weekends, and work shifts. Most packages can simulate shifts easily, but SIMPROCESS cannot.

In SIMPROCESS, a separate entity must be created, which interrupts the activities or workers, to simulate these breaks.

An important aspect of a simulation package is the ease and clarity with which it displays results for observation and analysis. Problems were encountered with the output reports of SIMPROCESS. After a simulation run, no reports were able to be viewed. Instead, a message was given, such as, "No data to display."

Documentation

The SIMPROCESS documentation was unclear and did little to lessen the difficulties encountered in learning this software system.

WITNESS Evaluation

General

WITNESS is activity based. When a work order arrives at a certain activity or location, all work delays and variable assignments are performed. The work order is then sent to its next location.

Advantages

Simulating when a work order changes, for example, from "new" to "carry over," is accomplished using a simple "CHANGE" statement. When editing, appropriate changes are made throughout the model automatically.

Disadvantages

Editing in WITNESS is difficult because the placement of the cursor does not correspond with the text that is being edited. The screen font is very small and difficult to read. No means were found to increase the font size.

Functional Characteristics

Problems were encountered in limiting the run length. The model would run until it was manually stopped. Use of global variables, attributes, and shifts is much easier in WITNESS than in SIMPROCESS. The animation in WITNESS is adequate and fairly easy to incorporate. Output reports in WITNESS are simple to view but are not very detailed.

Documentation

The documentation for WITNESS is good.

PROMODEL Evaluation

General

PROMODEL is activity based. A simulation is modeled as a network consisting of locations, and resources within the locations, which are connected via paths. A typical operation list in PROMODEL is shown in Figure 4. This figure shows the logic for two activities for "ALL" types of work orders. (In SIMPROCESS, each type of work order is handled separately.) The logic for routing and assigning values to attributes is fairly straightforward. In the simulation, a work order can be changed from "new" to "carry over" by simply modifying the output of the routing.

Advantages

Editing is easy in PROMODEL. Similar lines of code can be copied and pasted, which eliminates repetitive keyboard input. Creating the model was at least twice as fast using PROMODEL compared to the other two systems. When changes are made, PROMODEL queries the user if corresponding changes should be made throughout the model. The animation capabilities of PROMODEL are superior to the other two systems.

Process			Routing		
Entity	Location	Operation	Blk	Output	Destination
ALL	ProcWO	Use PWO for duration IF (cost = 3) THEN Route 1 ELSE Route 2 stts = 2 trec = Clock(hr)	1 2	ALL ALL	PrepICE SchDes
ALL	PrepICE	Use PICE for duration tced = Clock(hr) vf = 3	1	ALL	ObtCustA

Figure 4. A typical operation list in PROMODEL.

Disadvantages

No major disadvantages were discovered.

Functional Characteristics

The use of global variables, attributes, and shifts is similar to WITNESS. The reporting capabilities of PROMODEL are slightly more enhanced than those of WITNESS.

Documentation

PROMODEL has an extremely good documentation and tutorial package, which aids in the learning process.

5 Recommendation

Of the three simulation systems assessed, PROMODEL is recommended for use in DPW business process reengineering applications. It is easy to learn, it requires the least amount of labor hours to create a model, and its capabilities allow the user to create more valid models. Within the scope of this study, no weaknesses or problems were encountered in using PROMODEL. Although the other two simulation packages also have good features, they are lacking in some areas of interest to the Army.

Appendix: Activity Information

W Order

Start Year

Priority

New (NEW)	200 series
carry over (CO)	100 series
Subject to Availability of Funds (SAF)	300 series

Status

- Wait
- In progress
- Concept Design completed
- Design Completed
- Work Completed
- Rejected by customer

Times

- Received
- Started
- Cost Estimate Completed
- Concept Design completed
- Design Completed
- Work Completed
- Rejected by customer

Type

- New (NEW)
- Carry over (CO)
- Subject to Availability of Funds (SAF)

Cost

High (Hi)
Medium (Md)
Low (Lo)

Probability

New (NEW)

High	.25
Medium	.30
Low	.45

Carry over (CO)

High	.40
Medium	.35
Low	.25

Subject to Availability of Funds (SAF)

High	.30
Medium	.65
Low	.05

Urgent

Yes - .2 New work
No - All other work

Routine

Yes (r)

High	.20
Medium	.60
Low	.80

No (nr) - All others
Note: (t) is used for both R and NR

Funding Approval Dates (FAD)

Concept Design
Final Design
Full Design
Construction

Initialization and Generation

1. Randomly generate four (4) new work orders per week.

2. Initialize ten (10) carry over projects.

3. Initialize ten subject to availability of funds.

ACTIVITY BOX DURATIONS FOR AY4 SIMULATION MODEL

BOX	DESCRIPTION	ATTRIBUTE	DURATIONS
1.	Process Work Order	Urgent:	
		Lo-t/Md-r	3 hours
		Md-nr	6 hours
		Hi-t	8 hours
		Non-Urgent:	
		Lo-r	2 hours
		Lo-nr	4 hours
		Md-r	4 hours
		Md-nr	8 hours
		Hi-r	8 hours
		Hi-nr	12 hours
	Set status and time to in process. Transfer to activity 2: Lo-t, Md-r. Transfer to activity 6: Md-nr, Hi-t.		
2.	Prepare Initial Cost Estimate (3 People)	Urgent:	
		Lo-r	3 hours
		Lo-nr	6 hours
		Md-r	8 hours
		Non-Urgent:	
		Lo-r	2 hours
		Lo-nr	4 hours
		Md-r	4 hours
	Set completion of cost estimate.		
3.	Schedule Full Design	Urgent:	
		Lo-r	1 hour
		Lo-nr	2 hours
		Md-r	2 hours
		Non-Urgent:	
		Lo-r	2 hours
		Lo-nr	4 hours
		Md-r	4 hours

4.	Perform Full Design	Urgent:	
		Lo-r	5 days
		Lo-nr	16 days
		Md-r	75 days
		Non-Urgent:	
		Lo-r	8 days
		Lo-nr	25 days
		Md-r	90 days

Set completion design date.

5.	Perform Total Design by A/E	Urgent:	
		Hi-nr	200 days
		Non-Urgent:	
		Hi-nr	230 days

Transfer to activity 11: .50
Transfer to activity 14: .50

6.	Schedule Design	Urgent:	
		Md-nr	1 hour
		Hi-t	3 hours
		Non-Urgent:	
		Md-nr	1 day (8 hours)
		Hi-r	3 days
		Hi-nr	6 days

Transfer to activity 5: Hi-nr.
Transfer to activity 7: NOT Hi-nr.

7.	Perform Concept Design In House	Urgent:	
		Md-nr	5 days
		Hi-r	13 days
		Hi-nr	90 days
		Non-Urgent:	
		Md-nr	7 days
		Hi-r	120 days
		Hi-nr	160 days

Set status and time.

8.	Schedule Final Design	Urgent:	
		Md-nr	2 hour
		Hi-t	6 hours
		Non-Urgent:	
		Md-nr	2 days
		Hi-r	4 days
		Hi-nr	7 days
9.	Perform Final Design	Urgent:	
		Md-nr	11 days
		Hi-r	120 days
		Non-Urgent:	
		Md-nr	15 days
		Hi-r	150 days
		Hi-nr	260 days

Set status and time.

10.	Obtain Supplies	Urgent:	
		Lo-r	2 hours
		Lo-nr	4 hours
		Md-r	25 hours
		Md-nr	35 hours
		Hi-r	150 hours
		Hi-nr	240 hours
		Non-Urgent:	
		Lo-r	3 hours
		Lo-nr	6 hours
		Md-r	35 hours
		Md-nr	65 hours
		Hi-r	180 hours
		Hi-nr	290 hours
11.	Schedule Work	Urgent:	
		Lo-r	2 hour
		Lo-nr	3 hours
		Md-r	4 hours
		Md-nr	5 hours
		Hi-r	6 hours

		Non-Urgent:	
		Lo-r	3 hours
		Lo-nr	7 hours
		Md-r	9 hours
		Md-nr	10 hours
		Hi-r	11 hours

Check FAD construction time < clock time.
Transfer to activity 12: Md-nr, Hi-t
Transfer to activity 13: All others

12.	Perform Contracting Procedures	Non-Urgent:	
		Md-nr	120 days
		Hi-r	350 days
		Hi-nr	600 days
13.	Schedule Shops	Urgent:	
		Lo-r	2 hours
		Lo-nr	4 hours
		Md-r	6 hours
		Md-nr	8 hours
		Hi-r	10 hours
		Non-Urgent:	
		Lo-r	10 hours
		Lo-nr	25 hours
		Md-r	35 hours
		Md-nr	40 hours
		Hi-r	45 hours
14.	Perform Contract Work	Urgent:	
		Lo-r	2 hours
		Lo-nr	4 hours
		Md-r	15 hours
		Md-nr	35 hours
		Hi-r	150 hours
		Hi-nr	240 hours
		Non-Urgent:	
		Lo-r	3 hours
		Lo-nr	6 hours
		Md-r	35 hours
		Md-nr	65 hours

		Hi-r	210 hours
		Hi-nr	290 hours
15.	Obtain Customer Approval	Urgent:	
		Lo-t	3 hours
		Md-r	15 hours
		Md-nr	20 hours
		Hi-t	35 hours
		Non-Urgent:	
		Lo-r	15 hours
		Lo-nr	20 hours
		Md-r	35 hours
		Md-nr	48 hours
		Hi-r	60 hours
		Hi-nr	120 hours

16. Perform Contract Work

17. Verify Funding

    No: .10

    Yes .90

    Set Approval times:

    1. Cost Estimate Completed,
       Design not Completed:
       Set FAD Full Design. Transfer to activity 3.
    2. Concept Design Completed,
       Final Design Not Completed:
       Set FAD Final Design. Transfer to activity 8.
    3. Final Design Completed,
       Time less than 47 weeks:
       Set FAD Construction. Transfer to activity 11.
    4. Final Design Completed,
       Time Greater than 47 weeks:
       Set FAD Construction to first day of next year. Transfer to activity 11.

18. Perform Inhouse Work

PRICE LEVEL DEFINITIONS

Very Low	- VLo	-	o	$02K to 05K
Low	- Lo	-	o	$06K to 25K
Medium	- Md	-	o	$26K to 50K
High	- Hi	-	o	$51K to 100K
Very High	- VHi	-	o	> $100K

CUSTOMER PARTICIPATION LEVELS

CUSTOMER TYPE	PROBABILITY OF OCCURRENCE:
MISSION	0.45
BASE OPS	0.28
ENVIRON.	0.12
TRANSPORT	0.05
SECURITY	0.05
SP.REQUESTS	0.03
MISC.	0.02
	1.00

FACILITY JOB AREAS

EXTERNAL UTILITIES (Distribution/Collection Systems)	0.30
INTERNAL UTILITIES (Buildings)	0.25
GENERATING PLANTS	0.20
STRUCTURAL - Bldgs	0.15
STRUCTURAL - Bridges	0.10
	1.00

EXTERNAL UTILITIES:	
o Elec.Distribution Systems	0.30
o Steam Distr. System	0.20
o Water Distr. System	0.20
o Sewage System	0.20
o Street Lighting	0.10
INTERNAL UTILITIES:	
(Buildings)	
o Elec.Distribution Systems	0.30
o Steam Distr. System	0.20
o Water Distr. System	0.20
o Sewage System	0.20
o Interior Lighting	0.10
GENERATING PLANTS:	
o Electr.Equipment	0.25
o Elec.Distribution Systems	0.15
o Interior Lighting	0.15
o Steam Driven Equipment	0.15
o Steam Distr. System	0.10
o Water Distr. System	0.10
o Sewage System	0.15
STRUCTURAL - Bldgs	
o Repair of Str.Components	0.50
o Habitability Systems	0.25
o Protective Coatings	0.20
o Others	0.05
	1.00
STRUCTURAL - Bridges	0.10
o Repair of Str.Components	0.50
o Roadway Systems	0.25
o Protective Coatings	0.20
o Others	0.05
	1.00
	1.00

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